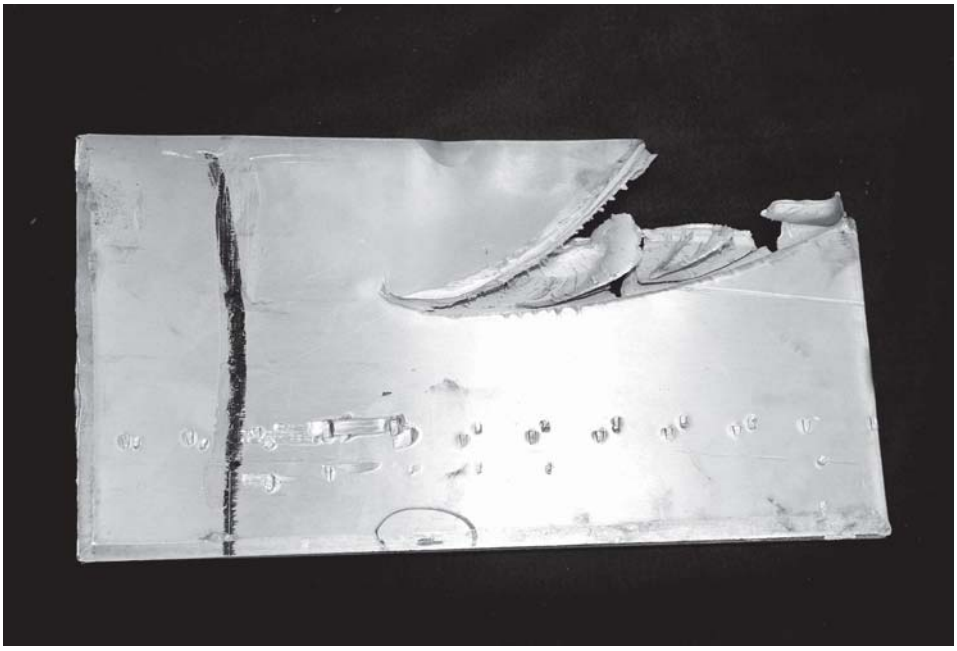
Industrial Technologies Program

Hot Rolling Scrap Reduction through Edge Cracking and Surface Defects Control

Reduces Hot Rolling Recovery Loss by 50 Percent to Improve Energy Efficiency

Hot rolling of large ingots is the dominant method of producing plate, sheet, and foil aluminum products. Hot rolling has typical recovery rate of about 82%, which means 18% of the original material is lost as planned end cut and scalping, or as incidental (unplanned) scrap. Hot rolled scrap is re-melted either to form fresh ingot material or to be used as secondary metal. Generally, scrap generation is due to edge cracking of hard alloys and surface defects of soft alloys. These defects can be significantly reduced if the slab material response to the hot rolling process is thoroughly studied to optimize processing parameters. Currently, processing parameters are determined by trial and error and largely based on experience, making it difficult to optimize the process and control scrap. This project will develop integrated computer models as process optimization tools to reduce scrap and improve energy efficiency in hot rolling.



Hot Rolling Edge Cracking

Benefits for Our Industry and Our Nation

- Potential energy savings of about 1.27 trillion Btu per year
- Potential cost savings of about $126 million per year
- Reduction of sulfur oxide (SO_x), nitrogen oxide (NO_x), carbon dioxide (CO_2), particulate, and volatile organic compound (VOC) emissions

Applications in Our Nation's Industries

This technology will add significant benefit to the domestic aluminum industry in energy saving and environment. It will also serve as a successful example of the integrated models for other manufacturing processes.

Project Description

The goal of the project is to develop integrated models for scrap reduction in hot rolling. The approach is to integrate microstructure characterization, computational modeling of microstructures and fracture nucleation, 3D rolling modeling, and process optimization. These models will serve as efficient process design tools to reduce scrap generation from edge cracking and rolling surface defects by 50 percent.

Barriers

The following are technical hurdles associated with the project:

- Characterization of the microstructure of alloy's initial material and its evolution in hot rolling to a level of detail that allows conversion into numerical model for simulations
- Development of computational models that incorporate the details of the alloy microstructures
- Establishment of a fracture and failure criterion that accounts for the details of microstructure and damage evolution
- Construction of 3D model of the roll/slab interaction of sufficient fidelity to capture the features necessary for accurate numerical simulation of hot rolling

Pathways

- Develop integrated models to link microstructure to macroscopic properties of aluminum and rolling process parameters
- Demonstrate predictive ability of the integrated model as a process optimization tool for hot rolling
- Use the integrated models/tools to reduce both planned and incidental scrap in hot rolling

Milestones

- Develop microstructural model for deformation and failure analysis
- Develop microstructure-based constitutive modeling and failure criteria
- Conduct 3D finite element simulation of hot rolling process
- Validate the mesoscale model of damage evolution and predict coupon-scale fracture results within 15%
- Conduct hot rolling experiments at laboratory scale and predict experimental results within 15% accuracy
- Conduct hot rolling validation at production scale and predict results within 15% accuracy

Commercialization

The end-product is a very complex 3D multi-physics simulation program that has not previously been accomplished in the studies of hot rolling. It can be commercialized immediately after the project completion. However, this process optimization technology must be customized to each hot rolling plant by defining variables such as pass schedule, lay-on temperature, heat or re-heat condition, friction condition, roll geometry, and rolling speed. This technology will be made available to the aluminum industry through journal publications and/or technical presentations.

Project Partners

University of Illinois at Urbana-Champaign
Urbana, IL
(Yonggang Huang: huang9@uiuc.edu)

Alcoa, Inc.
Alcoa Center, PA
(Dr. Ming Li: ming.li@alcoa.com)

Lawrence Livermore National Laboratory (LLNL)
Livermore, CA
(Moon Rhee: rhee1@llnl.gov)

Ohio State University
Columbus, OH
(Somnath Ghosh: ghosh.5@osu.edu)

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
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